Invasive plant pathogenic fungi in native Victorian ecosystems

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Abstract
Despite the introduction of hundreds of species of plant pathogenic fungi into Victoria over the last 200 years, *Phytophthora cinnamomi* is the only introduced fungus to have caused significant disease in native ecosystems. Of native plant pathogenic fungi, *Chalara australis* affecting Myrtle Beech is probably causing the most disease. Of fungi not yet present in Australia, Guava Rust *Puccinia psidii* and Sudden Oak Death *Phytophthora ramorum* are seen as the most significant potential diseases of native plants, while the Australian daisy rust *Puccinia lagenophorae* is a surprising invasive pathogen in Europe and North America. (*The Victorian Naturalist* **124** (1), 2007, 79-83).

Introduction

Of the more than 100 000 described species of fungi, approximately 10 000 can cause diseases in plants (Agrios 1997). Most plant species are affected by at least several different species of fungi, which are so well adapted to their hosts that they are unable to survive on any other material, but most of these do not cause significant disease in the plant (Alexopoulos *et al.* 1996). Disease can occur in all parts of the plant, although the roots and leaves are the most commonly affected. Root diseases can be quite striking as the infected plants are often unable to take up water, resulting in a complete collapse of the plant (if it is herbaceous), or rapid dieback of the leaves (if the plant is woody). Foliar diseases are easier to diagnose as the fungi usually produce discrete leaf lesions where they produce microscopic spores that are dispersed by wind and rain. Most plant pathogenic fungi, particularly those that cause foliar disease, are quite host specific, i.e. they only infect a single species of plant, or its close evolutionary relatives (Agrios 1997). There are fewer root pathogenic fungi, but these often affect a much wider range of plants.

There is a balance between plants and their pathogens in their natural environments. If a fungus killed an entire plant population, then the fungal population would also die out, as it would not have a host plant to live on. Eucalypts, for example, are affected by a very large number of fungal species (Keane *et al.* 2000), but these rarely cause serious disease in their native habitats. In plantations some of these can be serious pathogens. This is generally true for all plants that are brought into cultivation. As the crops become more genetically uniform and are grown repeatedly in the same soils, the balance between host and pathogen shifts to a point where a pathogen can become extremely aggressive and can destroy a crop (Agrios 1997).

Another way in which a pathogenic fungus can become very destructive is by introducing it to a new environment. The pathogen can jump onto new plant species and quickly cause significant disease or death. It is in these situations that the pathogen becomes truly invasive (Anagnostakis 1987). Luckily, there are not many serious cases of this happening, especially in Australia, but there are several species of plant pathogenic fungi expected to become serious invasive pathogens were they to be introduced into Australia. This paper will briefly discuss the two exotic species that are likely to become extremely invasive if they are introduced to Victoria. A rare example of an Australian fungus that has become invasive in Europe and North America will also be discussed. But first we will look at a North American example of a very serious invasive plant pathogenic fungus, and then two most important invasives in Victoria; one of which has been introduced, while the other is probably native.

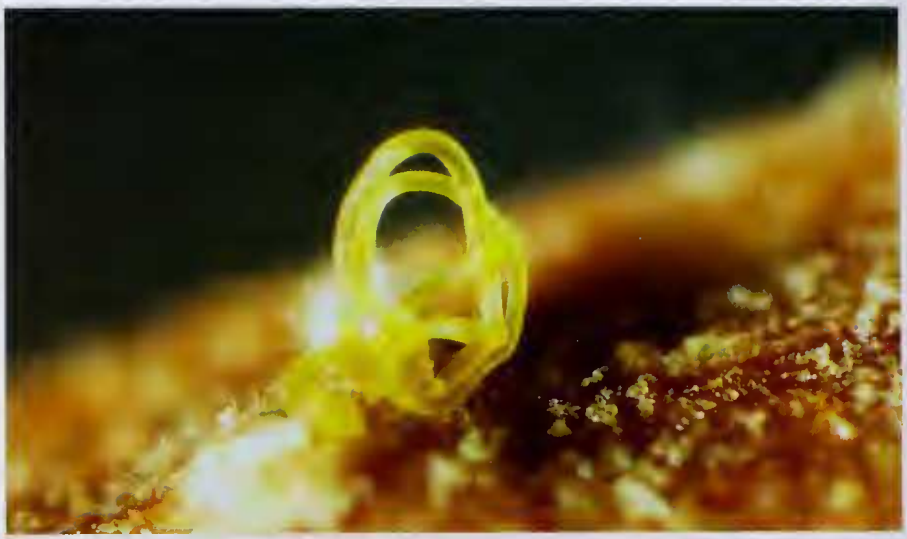

Fig. 1. *Cryphonectria parasitica* spores oozing from an infected chestnut stem. AQIS post entry quarantine station, Knoxfield, 2001. Photograph by Robin Eichner.

Fig. 2. Section through rust pustule of *Puccinia lagenophorae* showing two-celled teliospores. Specimen on *Lagenophora stipitata* from Daniel McAlpine collection, Kiewa Valley, 1902. Scale bar equals 40 µm.

Chestnut Blight in North America

The damage done by Chestnut Blight in North America can be used to appreciate the disastrous effects that a plant pathogenic fungus can have when introduced into a new geographical area. In 1905, American Chestnut *Castanea dentata* trees outside the New York Zoological Garden were reported to be dying (Anagnostakis 1987). Symptoms included bark cankers (lesions) and wilting of distal foliage. The causal agent was identified as the fungus *Cryphonectria parasitica* (an ascomycete). Native to Asia, *C. parasitica* is a minor pathogen of Japanese and Chinese

Chestnuts, *Castanea crenata* and *Castanea mollissima* respectively, but an extremely aggressive pathogen of American Chestnut. Once it arrived in North America, presumably on plants imported from Asia, it spread at a rate of about 37 km per year. The fungal spores are transported on the surfaces of animals and through rain splash. By the mid 1950s it was estimated that about 3.6 million hectares of American Chestnut trees were dead or dying. These trees were once a major component of the hardwood forests of the eastern United States, but now exist only as stems and stumps that continually re-shoot, only to become infected. If Chestnut Blight were to reach Australia it would destroy our, admittedly small, Chestnut industry. In 2001, Chestnut plants from Spain were about to be released from quarantine facilities in Victoria, when small lesions were found on the stems on one of the plants. Microscopic examination and fungal culturing revealed that it was infected with Chestnut Blight (Fig. 1). The plant appeared healthy during the two years it had spent in quarantine (Cunnington and Pascoe 2003).

The Cinnamon Fungus

In Australia the most invasive plant pathogenic fungus is the Cinnamon Fungus *Phytophthora cinnamomi* (an oomycete). Originally described from Cinnamon in the mountains of tropical Western Sumatra, *P. cinnamomi* needs little introduction to Australians, so will be mentioned here briefly. In Victoria it is the sclerophyll forests that are most affected by Phytophthora dieback (Weste 1974). Typically, susceptible trees and shrubs die back, to be replaced by relatively resistant grasses and sedges. Those plants most susceptible include species of *Xanthorrhoea*, Epacrid-aceae, *Acacia*, Myrtaceae, Fabaceae and Proteaceae. The impact of *P. cinnamomi* is so significant that it was listed as a 'Key Threatening Process' in the Common-wealth Environmental Protection and Biodiversity Conservation Act 1999. Hardham (2005) presents a recent review of *P. cinnamomi*.

Myrtle Wilt in Victoria and Tasmania

Myrtle Beech *Nothofagus cunninghamii* is a dominant tree in cool temperate rainforests in Victoria and Tasmania. The disease known as Myrtle Wilt was first reported in 1973 in north-western Tasmania, where areas of Myrtle Beech were noticed to be dying back. The causal agent, *Chalara australis* (anamorphic fungus) was not described until 1989 (Kile and Walker 1987). It is thought to be indigenous to south-eastern Australia. Myrtle Wilt has been found throughout cool temperate rainforests in Tasmania, and in the Otway Ranges, Central Highlands and Strzelecki Ranges in central and southern Victoria (Cameron and Turner 1996). The fungus is spread by airborne and waterborne spores that infect through wounds in the outer bark. It may spread from tree to tree via root contact or grafts. Death occurs six months to three years after infection. There is still some uncertainty regarding the natural status of Myrtle Wilt, given that it occurs in both disturbed and undisturbed sites, and that it has only reached epidemic levels in the past 30 years. If *C. australis* is truly an indigenous fungus, it is unusual that it has evolved to become an aggressive pathogen of its only host.

Exotic pathogens

The two plant pathogenic fungi that do not yet occur in Australia and are most likely to cause serious disease to native plants in Victoria are Guava Rust *Puccinia psidii* and Sudden Oak Death *Phytophthora ramorum* . *Puccinia psidii* (a basidiomycete) is a rust fungus native to South America. It infects leaves and stems, forming yellow spore-filled pustules. Infected leaves shrivel, and in heavily affected trees, severe defoliation can occur. The fungus occurs naturally on native South American plants in the subfamily Myrtoideae of the Myrtaceae, but also infects Australasian plants in the subfamily Leptospermoideae such as *Eucalyp-tus*, *Melaleuca* and *Callistemon* (Simpson *et al.* 2006). Its distribution appears to be spreading from tropical South America into more temperate regions in Central America, where it occurs as far north as Florida. In 2005 *P. psidii* was found in Hawaii on *Psidium*, *Eugenia* and *Metrosideros*. It is probably the most serious threat to native ecosystems in Australia.

Phytophthora ramorum (an oomycete) was described from Europe in 2001 where it was killing *Viburnum* and *Rhododendron*

(Werres *et al.* 2001). At that time the disease was known as 'Ramorum Dieback', but the fungus reached North America, where in California, it is currently killing very large numbers of oaks. This has led to a new common name for the disease, 'Sudden Oak Death'. *Phytophthora ramorum* is now known to affect over 100 species of plants from 30 families. Depending on the plant, the fungus can cause lethal cankers, shoot blights or leaf blights. It produces spores that are spread by wind and rain. The origin of *Phytophthora ramorum* remains unknown. The European and North American forms appear to be distinct, and may warrant separate subspecies. Both forms were probably recently introduced into their respective continents. Presumably they have arrived on plants, or plant products, from other parts of the world. Asia is often suggested as its origin, as large numbers of *Rhododendron* species are affected by *P. ramorum*, and the centre of diversity for *Rhododendron* is in Asia. The effect this fungus could have on native Australian ecosystems is also unknown given its wide host range and unpredictable pathogenicity.

Puccinia lagenophorae on composites

In the early 1960s a new rust fungus was reported causing leaf lesions on Groundsel *Senecio vulgaris* in Britain, France and Switzerland (Wilson *et al.* 1965). Its origin was unknown, and it was described as the new species *Puccinia terrieriana*. By 1965 it was very widespread in Britain and cross-infectivity studies using its air-borne spores revealed that it could infect other composites including Cineraria *Senecio cruentus*, English Daisy *Bellis perennis* and Calendula *Calendula officinalis*. A comprehensive examination of similar rust fungi revealed that it was not a new species, but rather the Australian native fungus, *Puccinia lagenophorae* (Wilson *et al.* 1965). Described in 1884, *P. lagenophorae* (Figure 2) infects several genera of Australian Asteraceae, including *Lagenophora*, *Calotis* and *Podotheca* (McAlpine 1906; herbarium VPRI and DAR records). Sixty species of composites are now known to be susceptible. The fungus has since moved to North America (Scholler and Koike 2001), where it has created some concern over the effect it may have on the 100 or so native species of *Senecio* (Littlefield *et al.* 2005). Although it does not cause serious disease in Europe and North America, *P. lageno-phorae* is a good, but very rare, example of a plant pathogenic Australian fungus that is invasive in other parts of the world.

Final remarks

Over 200 species of plant pathogenic fungi have been introduced into Victoria in the last 150 years (Cunnington 2003). But, almost all of these have since infected only the plant species they were introduced with. Even those few introduced fungi that affect a wide range of introduced cultivated plants have not moved into native systems. Only *P. cinnamomi* has become a truly invasive plant pathogen in Victoria, yet the damage caused by this single invasive organism has been devastating. With the increasing movement of agricultural products around the world, quarantine legislation and inspection regulations continue to improve (Palm 1999). But even in Australia, where quarantine regulators are heavily funded, several new plant pathogenic fungi become established each year. We can probably consider ourselves fortunate that more plant pathogenic fungi have not become invasive in our native ecosystems.

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Contingency planning and prioritising pest plants

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Weed control is an emotive issue and all land managers have to deal with it, often with limited funds. Land managers, however, are usually motivated to prioritise control of weeds having an obvious impact on their use of the land, for example those that are already well established and abundant. Recently, an increasing focus has been given to preventing weed spread early in the invasion process, that is, by attempting to eradicate particular species long before they expand and become widespread. Land managers need to identify the present and future priority weeds so that resources can be focused on them. This paper describes a generic process or contingency plan to assist in developing either local, regional or state plans to identify and act upon new and emerging pest plants. (*The Victorian Naturalist*, **124** (2), 2007, 83-86)

Introduction

Preventing the naturalisation of potentially invasive species is accepted as the first and most cost-effective option for dealing with biological invasions (Wittenberg and Cock 2001). Moreover, economic modelling suggests that preventing the spread of new pests can generate a benefit-cost ratio of up to 38:1, far exceeding most other forms of government investment (AEC group 2002).

Currently, it is estimated that at least 27 009 non-native plant species have been imported into Australia (Virtue *et al.* 2004). While it is difficult to predict how many of these will become invasive, nearly 8000 have documented histories as invasive species somewhere in the world and over 3000 of these already have naturalised somewhere in Australia (Randall 2006). It is possible that tomorrow's weeds, potentially over 4900 species, are being sold as garden plants right now.

Recent (1970 – 1995) plant introductions into Victoria

A total of 135 new vascular plant species were recorded as introduced into Victoria between 1970 and 1995. The number naturalising per year is shown in Fig. 1 and a regression indicates that the rate of new introductions is increasing, with the present average of 7.3 new plants establishing per year with an annual increase of 0.25 plants each year. Predominantly these new plants have originated from South Africa and Europe, and have been introduced deliberately as ornamental plants. The most common new invaders into Victoria are from the families Iridaceae and Poaceae in the Monocots; Salicaceae, Fabaceae, Asteraceae and Malaceae in the Dicots; and Pinaceae in the Conifer group (Groves and Hosking 1997).